



**National Transportation Safety Board**  
Washington, D.C. 20594

*Report Date: April 9, 2012*

**Enbridge Line 6B Pipeline Information & History Group Chairman's Factual Report**

**A. Accident Identification**

Operator: Enbridge Energy, Limited Partnership  
Source: Line 6B  
Location: Marshall, Michigan  
Commodity: Crude Oil  
Date/Time: July 25, 2010, 5:58 p.m.  
NTSB No.: DCA-10-MP-007

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### **C. Accident Summary**

On the evening of Sunday, July 25 2010, about 5:58 p.m.<sup>1</sup>, the Enbridge Energy (Enbridge) control center in Edmonton, Alberta Canada, was in the final stages of executing a scheduled shutdown of their 30-inch diameter crude oil<sup>2</sup> pipeline (Line 6B). As the last pump was stopped, a segment, located approximately ¾ of a mile downstream of the Marshall, Michigan pump station, ruptured. The initial and subsequent alarms associated with the event were not recognized as a line break through two start ups and over multiple control center shifts. Residents near the rupture site began calling the Marshall City 911 dispatch center to report odors at 9:25 p.m. on Sunday; however, no calls were placed to the Enbridge control center until 11:17 a.m. the following day. Once the Enbridge control center was notified, nearly 17 hours after the initial rupture, remote controlled valves were closed, bracketing the ruptured segment within a three-mile section.

The accident resulted in an Enbridge reported release estimate of 20,082 barrels (843,444 gallons) of crude oil with no injuries or fatalities. The rupture location is in a high consequence area<sup>3</sup> within a mostly rural, wet, and low-lying region (that is, wetlands). The released oil pooled into a marshy area over the rupture site before flowing 700 feet south into Talmadge Creek which ultimately carried it into the Kalamazoo River.

Line 6B was constructed in 1969 as a 293-mile long extension of the Lakehead pipeline system, stretching from Griffith, Indiana to Sarnia, Ontario, Canada. The failed segment was a cathodically protected, tape-coated pipe manufactured by Italsider s.p.a.<sup>4</sup> per the API 5L X52 specification with 0.25-inch thick wall and a double submerged arc welded (DSAW) longitudinal seam. The maximum operating pressure (MOP) for Line 6B was 624 psig; however, at the time of the accident, this segment was under a 523 psig Enbridge imposed pressure restriction. The maximum-recorded discharge pressure at Marshall, prior to the rupture, was 486 psig.

### **D. Pipeline Information**

#### **1. Enbridge Lakehead System and Line 6B**

The Lakehead system, including line 6B, was originally operated under the name Lakehead pipeline partners, which was changed around 2001 to Enbridge Energy Partners. Enbridge Energy Partners (EEP) limited partnership is a publicly traded company with around 66 percent public interest with the remaining 34 percent ownership split between Enbridge Energy Inc.<sup>5</sup> and Enbridge Energy Management LLC. The Lakehead system is owned by the partnership but operated by Enbridge Inc.

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<sup>1</sup> All times are expressed in local accident time, Eastern Daylight Time.

<sup>2</sup> Line 6B transports various batch types of diluted bituminous crude oil (tar sands crude) that will be referred to as crude oil in throughout this report.

<sup>3</sup> As defined by PHMSA under 49CFR§195.450.

<sup>4</sup> Societa Per Azioni (Italian). The Italsider pipe was purchased from Siderius Inc. of New York.

<sup>5</sup> Initially incorporated as Interprovincial Pipe Line in 1949 the company changed its name to Enbridge Inc. around 1998

The Lakehead system is United States' portion of the Enbridge liquids mainline that stretches 1,900-miles from the border at Neche, North Dakota, to Superior, Wisconsin, and into Chicago, Illinois, before travelling northeast through Indiana and Michigan to deliver western Canadian bituminous crude oil to terminals in the upper Midwest and Sarnia, Ontario. As of early 2010, the Lakehead system included<sup>6</sup> lines 1, 2A, 2B, 3, 4, 5, 6A, 6B, 10, 13, 14, 64, 61, 65 and 67. Combined, these lines traverse over 4,400 miles of US territory with diameters ranging from 12-inch to 48-inch with installations dating back to the 1950's. Over 1,300 miles of pipe are identified as high consequence areas<sup>7</sup> (HCA) under the Enbridge HCA plan and approximately 25 percent of the U.S. mileage consists of polyethylene tape coated lines

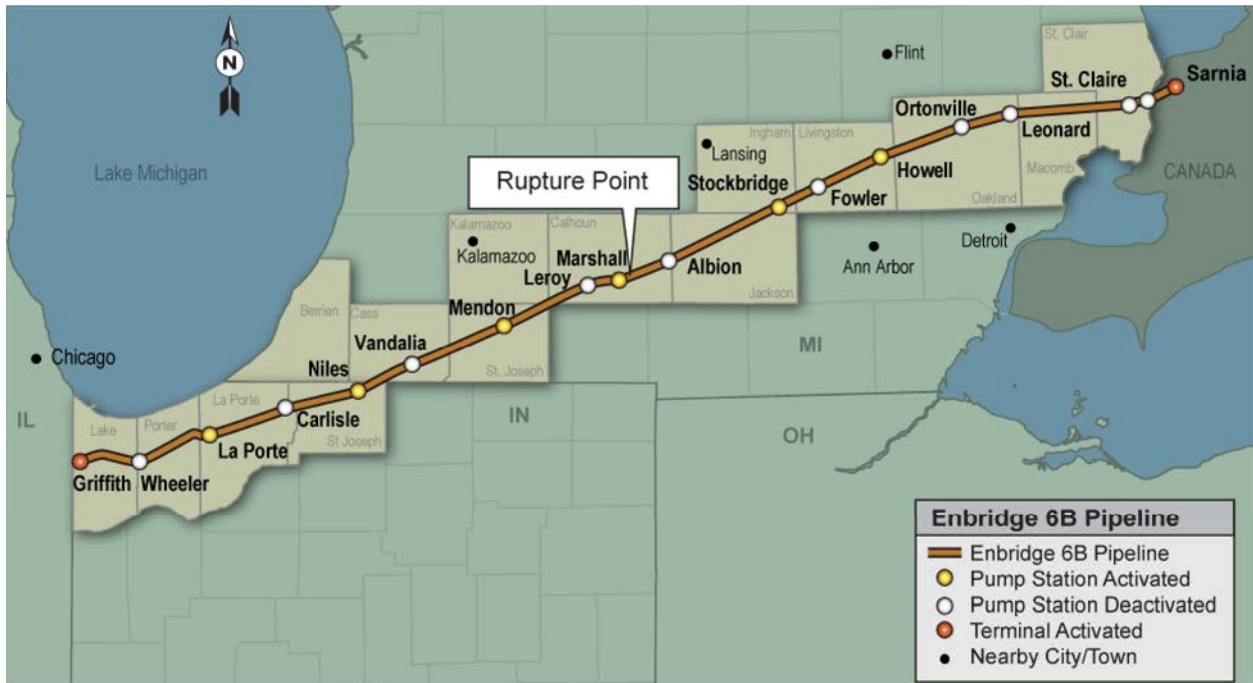


**Figure 1.** Enbridge Lakehead System

Enbridge records indicated that the Lakehead system has a design throughput of 2.5 million barrels per day and that the company transports approximately 12 percent of the total US Oil imports while deliveries to Ontario, Canada satisfy approximately 60 percent of refinery demand in that region. The Enbridge 2010 annual report showed that the liquids pipeline business unit overall had average delivery volumes in 2010 of 2.17 million barrels per day (bbls/day), which represented an increase of 114,000 bbls/day from the previous year.

<sup>6</sup> Excluding line 7 (153 miles); Line 10 ( 91 miles), and Line 11 (47 miles)

<sup>7</sup> Defined under 49CFR§195.450



**Figure 2:** Line 6B – 293 mile span from Indiana through Michigan and into Sarnia, Ontario Canada

## 2. Line 6B Configuration

Line 6B was constructed in 1969 as a 293-mile long, 30-inch diameter, extension starting in Griffith, Indiana and traversing Michigan, over the St. Clair River, into Sarnia, Ontario Canada. The U.S. portion of line 6B measures approximately 286 miles long and is comprised of mostly 0.25-inch and 0.312-inch wall pipe. As of 2010, line 6B had a stated design throughput of 283,000 barrel per day<sup>8</sup>. Line 6B was listed as transporting mostly heavy crudes from injection points at Griffith and Hartsdale, Indiana to terminals near Stockbridge and Marysville, Michigan and into Sarnia, Ontario, Canada.

According to the Enbridge alignment sheets, the ruptured segment of line 6B is listed as a 30-inch OD x 0.25-inch wall thickness, API 5L x52 pipe wrapped with a Polyken® 960 tape<sup>9</sup>. A GPS survey conducted following the accident, at the location of the failed segment, identified the rupture occurred between girth welds numbers 217720 and 217730 at a downstream distance of approximately 0.60 miles from the Marshall pump station near MP608.22. Enbridge submitted documentation showing depth of cover for line 6B in the rupture area; however, it was not clear from the information provided at what the depth of cover was for the failed segment. The survey sheets indicated depths of up to approximately 50-inches below grade.

<sup>8</sup> The facility response plan uses a higher design flow rate for calculating a worst case discharge.

<sup>9</sup> Polyethylene tape

Line 6B is the only oil transmission pipeline operating in its right of way. Running parallel to line 6B was a 42-inch diameter Vector natural gas transmission pipeline. Vector pipeline was operated by Enbridge out of the Houston control center. The transmission line delivers gas to companies such as Consumers Energy and Michigan Consolidated Gas Company.

Line 6B operated with seven active pump stations between Griffith and Sarnia with spans of 30 to 40 miles between each station. Table 1 below summarizes the stations locations and approximate elevations.

**Table 1:** Line 6B Pump Stations

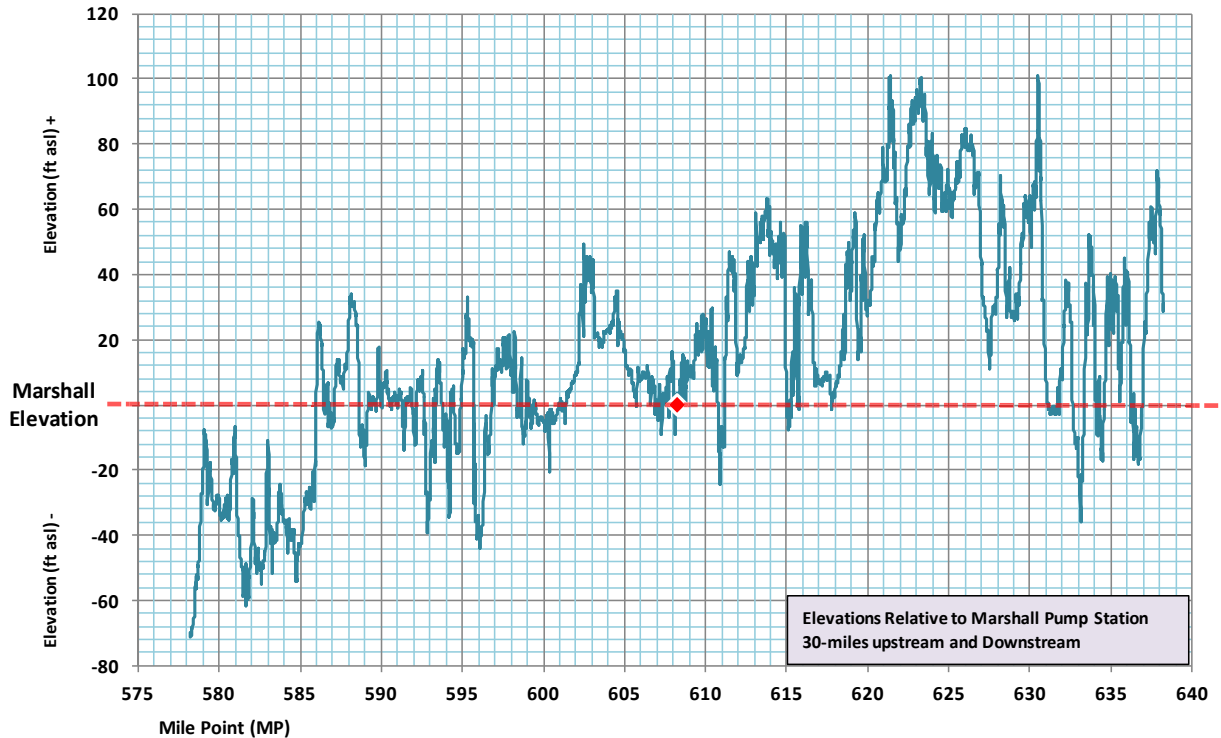
Active Pump Station	Approx. Mile Post	Approx. Elevation (feet asl)
(Griffith Terminal) Active	465.6	628
(LaPorte Station) Active	499.4	792
(Niles Station) Active	538.2	796
(Mendon Station) Active	576.9	840
(Marshall Station) Active	607.6	920
(Stockbridge) Active	650.6	950
(Howell Station) Active	678.7	971.8

The elevation profile shown on the alignment sheets and data from the 2004 geometry tool inspection report the elevation of the upstream girth weld on the ruptured segment was located approximately 918.64-feet above sea level (asl).<sup>10</sup> A GPS survey conducted at the time of the accident pipe excavation reported the elevation as 911 feet above sea level at the location of rupture. (See figure 5). An elevation profile of Line 6B plotted approximately 30 miles upstream and downstream of the Marshall Pump station<sup>11</sup> shows an average elevation of 933 feet above sea level (asl) with a maximum elevation of 1,019 feet asl and a minimum 847 feet asl. These are plotted in Figure 3 relative to the Marshall Pump station elevation.

Pump stations along Line 6B operated with three to five pumps constant speed rated from 1,250 to 2,500 bhp and arranged in parallel. (See figure 4). Each is equipped with remotely operated suction and discharge valve and separated by check valves. Line 6B includes 33 mainline valves that can be remotely operated to isolate sections of the pipeline. Two of these valves are operated at MP576 and MP 650 during a line 6B shutdown.

<sup>10</sup> A survey conducted at the accident site following the rupture and release indicated an elevation at the rupture location of 911 feet ASL (refer to IR 43)

<sup>11</sup> Between MP576 and MP638



**Figure 3.** Line 6B elevation (relative to the Marshall elevation @ 918 ft ASL) profile upstream and downstream of the Marshall pump station (~MP 608)

### E. Site Description

The release of heavy crude oil occurred on Enbridge’s Line 6B, near MP608.22 in Marshall, Calhoun County, Michigan, in an undeveloped agricultural area south of town approximately 0.4 miles west of US 227 and approximately 0.2 miles south of Division Drive. The majority of the released oil entered a low-lying wetland between the breached pipeline and Talmadge Creek. Vegetation in the release area consisted of wetland plants in low lying area, and brush and trees in upland areas.

The rupture location was identified under the Enbridge HCA management plan as an Other Population High Consequence Area. The area of the rupture is listed on the Enbridge alignment sheets as swamp-woods. Within the 5-mile span shown on the alignment sheet, there are six utility crossings shown. The nearest utility crossing line 6B was a 10-inch Michigan gas pipeline, installed in 1952. The Michigan gas line was located approximately 525 feet downstream from the rupture.

### F. Cathodic Protection

Line 6B was protected from corrosion using both, a Polyken, polyethylene tape wrap and an impressed current cathodic protection system. The nearest rectifier station was located at the Marshall Pump station upstream from the rupture location. Pipe to soil readings taken on July

31, 2010, following the accident, showed that cathodic protection levels exceeded the acceptable ranges as required under 49CFR 195.571, with the Enbridge rectifiers interrupted. Tests were conducted again on August 11, 2010 with all nearby rectifiers interrupted, including adjacent utilities. Pipe to soil readings with rectifiers on read approximately -1.75V and nearly -1.45V with rectifiers off.

### **G. Pipeline History**

The ruptured pipe segment was manufactured to a 1969 API 5LX 16th Edition, Grade 52 specification with 52,000 psi minimum yield stress. The line was cold expanded under hydrostatic pressure (1,050 psig) to its final outside diameter. Mill Certificates, bills of lading and hydrostatic test information were provided to the NTSB by Enbridge. The failed segment of pipe was double submerged arc welded purchased from Siderius Inc. and manufactured by Italsider s.p.a.

Enbridge construction documentation for Line 6B included specifications, inspection reports, mechanical testing, chemical analysis and hydrostatic test results. Enbridge was unable to identify which heat number was associated with the failed pipe segment [IR83]. The documentation provided by Enbridge shows that the installation of line 6B was completed in late 1969 and was constructed from approximately 95 miles of flash welded pipe manufactured by AO Smith and approximately 191 miles of double submerged arc welded pipe manufactured by Italsider s.p.a.

The original purchase order for 30-inch pipe was issued to Siderius Inc. of New York on November 14, 1968. In the purchase order, approximately 190 miles of 0.25-inch wall API grade X52 pipe and 1.2 miles of 0.50-inch wall API grade B pipe were purchased to the latest edition of the API specifications. The supplemental specifications to the purchase order allowed a flash welded, electric resistance or double submerged arc welded longitudinal seam and required that the purchased pipe be hydrostatically tested after installation to a pressure not to exceed 100 per cent of the specified minimum yield stress (SMYS), at the low point in the line, using the U.S.A.S B31.4<sup>12</sup> standard. Hydrostatic test results conducted at the Italsider Steel mill in Italy in 1969 as well as the construction hydrotesting results performed on November 22, 1969 were provided to the NTSB. Hydrostatic testing at the mill consisted of a 10 second test to 780 psig, immediately following the expansion process.

The Enbridge supplemental requirements to the specifications dictated that the pipe was to be inspected during manufacturing and that chemical properties and mechanical tests are conducted. Furthermore, the mill was to conduct one hydrostatic test to destruction from the initial lot of 100 lengths. The burst test was included in the paperwork supplied by Enbridge showing that a burst pressure of 1,365 psig was obtained at the mill producing a fish-mouth rupture 1.45 inches above the long seam, measuring 6.33 feet in length and 7.67 inches at its widest point. Wall thickness measurements varied from 0.202 to 0.187 inches along the rupture.

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<sup>12</sup> Currently the ASME B31.4 "Pipeline Transportation Systems for Liquid Hydrocarbons and Other liquids"

A final inspection report, dated March 18, 1969, was provided to Enbridge from the Moody Engineering Company for the Italsider pipe. The inspection was performed against the API Std. 5LX 15th edition, dated March 1968, for the 0.25-inch wall pipe and the API Std. 5L, 23rd edition, dated March 1968, for Grade B 0.50-inch wall pipe. The inspection report stated that a hydrostatic mill test was performed to 780 psig on the 0.25-inch wall pipe and 880 psig on the 0.50-inch wall pipe after going through a cold expansion process and with the retaining dyes removed.

The inspection report noted that the chemical analysis of the various heats met the requirements of the API and Enbridge specifications and that the mechanical tests were within the API specified allowance for yield and tensile stress. The lowest yield strength recorded was 55,049 psi and the lowest tensile strength recorded was 76,813 psi for the 0.25 inch wall pipe. The inspection report indicated that no weld repairs were allowed to the long seam after the expansion process with the added remark that very little weld repair was carried out. The average length of the grade X52, 0.25-inch wall pipe was reported as 38-feet and 11-3/64-inches.

Upon fabrication, the Italsider pipe was shipped bare from Taranto, Italy, to the Port of Windsor Ontario, through the St. Lawrence Seaway. Packing lists indicate that nearly identical numbers of pipe were loaded on the S.S. Himmerland around August 19, 1969, and the S.S. Pacific Skou around September 14, 1969. Inspection reports completed after the pipe was loaded onto the vessels showed that some pipe was sent back to the mill for rework due to dents or damaged bevels. Purchase agreements supplied by Enbridge detail the arrangements to deliver the pipe from Windsor to multiple staging sites within Michigan by truck.

Enbridge construction records for the failed segment show that it was hydrostatically tested as part of a 3.47-mile section on November 21, 1969. Water from the Kalamazoo River was pumped into the pipeline section to a pressure of 798 psig and monitored for 24 hours. According to the test report, the section was accepted with no leaks or ruptures were reported. The certification letter dated February 3, 1970, indicates that this section was tested to a minimum pressure of 783 psig and a maximum of 820 psig.<sup>13</sup>

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<sup>13</sup> The 820-psig reading was the lowest elevation in the test section and the 783-psig was the highest elevation.



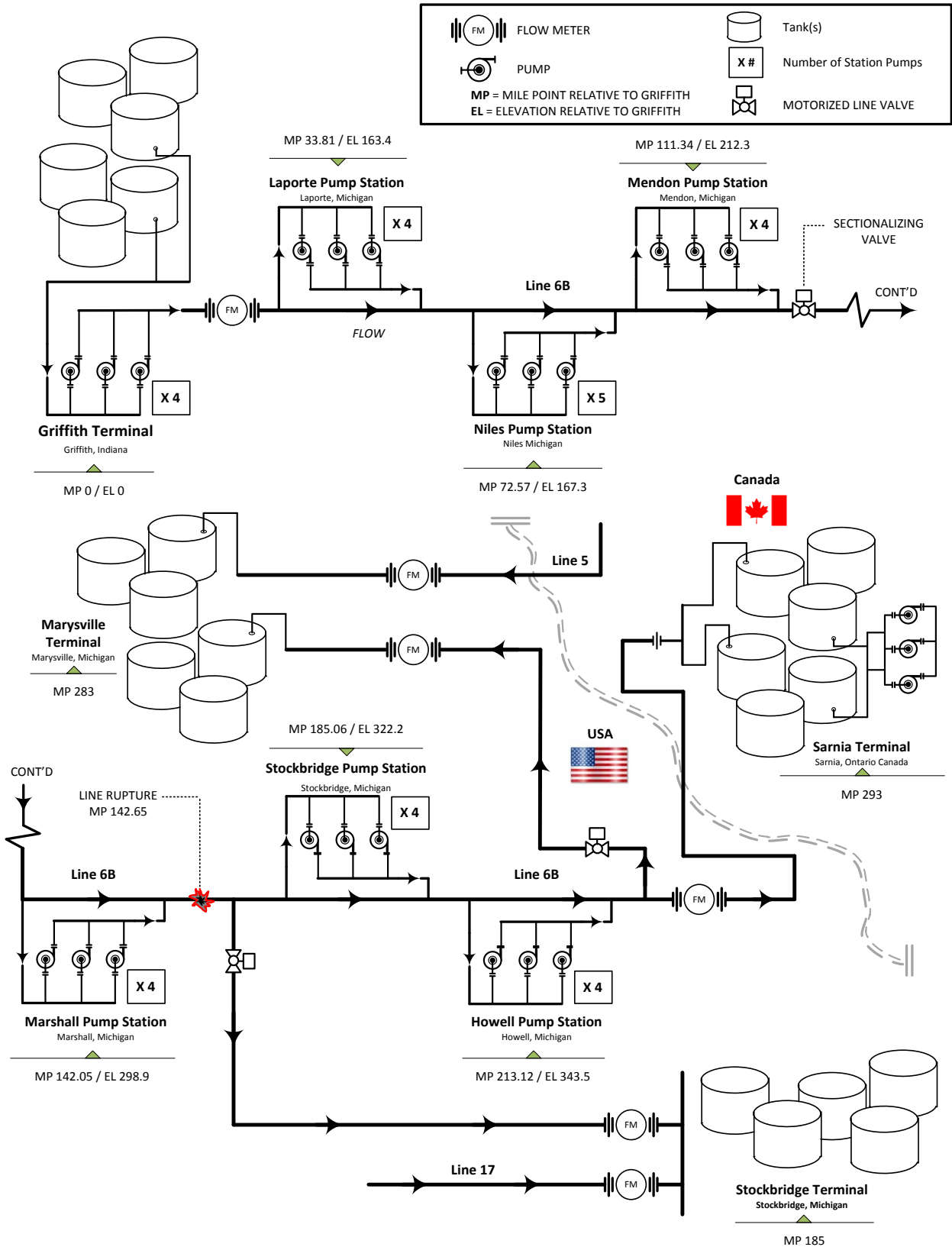


Figure 4. Line Diagram of Line 6B Delivery Locations

## H. Previous Line 6B Leak and Repair Reports

Enbridge supplied eleven leak reports for Line 6B dating back to 1970, as shown in Table 2. None of the reports involved the failed segment. Two of the incidents were reportable events to PHMSA. A majority of the reports were leaks located 64 miles or greater downstream of the accident location.

**Table 2.** Previous Leaks on Line 6B

Enbridge Previous Leaks Recorded on Line 6b			
Date	Milepost	Listed Cause	Release (bbls)
06/17/1970 <sup>14</sup>	468.51	Pin hold leak in seam	3
11/15/1978	475.30	Three intersecting gouges on pipe with 2" crack at intersection	70
01/11/1984	512.27	Corrosion from Cathodic Protection interference	5
06/26/1995	671.96	External corrosion with pit; 2" long x 1.5" circular	0
04/07/1978	682.77	Line buckled at casing with two pin hole leaks	4
01/09/1979	714.93	Not provided	Not reported
07/30/1987	716.32	Rock at 6:30 dented line	1
06/16/1988	722.81	Idle line over-pressure (thermal expansion)	8,500
05/12/1987	749.93	External corrosion with pitting	2
04/30/2010	751.07	External corrosion approximately 4" in diameter	10

<sup>14</sup> Another repair entry was supplied for this same leak. This repair showed the pipe segment was replaced in August and September 1970.

Permanent repair reports for Line 6B—going back for the previous two years contain no work for the area near the accident site. Corrosion reports and their corresponding repair report indicate eight entries with stress corrosion cracking (SCC). All of the locations are downstream of the accident location, summarized in Table 3. Fieldwork requests provided to the NTSB from Enbridge, for the three-months prior to the accident date, showed no work on Line 6B at the accident location.

**Table 3.** Permanent Repair Reports for SCC on Line 6B

Line 6B Permanent Repair Reports Identifying SCC				
Date	Milepost	Repair	Length (in)	Max Depth (in)
5/5/10	723.55	Grinding	3.8	0.035
4/10/10	741.37	Sleeve	0.1	0.115
4/19/10	741.56	Sleeve	1.1	0.167
4/8/10	743.12	Sleeve	0.1	0.11
2/17/10	748.16	Sleeve	2.5	0.129
3/26/10	750.09	Sleeve	1.7	0.136
3/16/10	750.79	Sleeve	1.4	0.145
3/3/10	751.01	Sleeve	1.2	0.128

### I. Pressure Restrictions on Line 6B

Over 1,100 Enbridge-imposed integrity-related pressure restrictions have been put in place on Line 6B going back to 2003. Of these pressure restrictions, 94 percent were listed as corrosion related followed by crack features which represented approximately 2.6 percent of the total. This 2.6 percent was nearly equally split, in number, between upstream and downstream locations relative to the accident site. The nearest crack and corrosion indications are listed in the following tables.

**Table 4.** Crack Indications requiring pressure restrictions near the accident site

MP	Feature	Pressure Reduction	2010 Status	Date
546.8821	Crack	600	Ok	8/4/2006
602.6693	Crack	603	Active	8/4/2006
622.19	Crack	593	Active	8/4/2006

**Table 5.** Corrosion Indications requiring pressure restrictions near the accident site

MP	Feature	Pressure Reduction (psig)	2010 Status	Date
604.240	Corrosion	563	Removed	12/17/2008
608.770	Corrosion	607	Active	12/14/2009
610.229	Corrosion	591.55	Active	6/3/2010
610.232	Corrosion	602	Active	12/14/2009
610.239	Corrosion	607	Removed	12/14/2009

**J. Previous Line 6B shutdowns**

From 2007 until the time of the date of the accident, Enbridge shows 511 instances where Line 6B was shutdown. The duration of the shutdowns ranged from 10 minutes to 61 hours, with an average time of 13 hours. There were 77 shutdowns from January 2012 through July 26, 2010. Line 6B had been shutdown most recently on July 22 and 24.<sup>15</sup>

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<sup>15</sup> The operator on July 22 shutdown was Operator B1 and on July 24 Operators A1 and A2

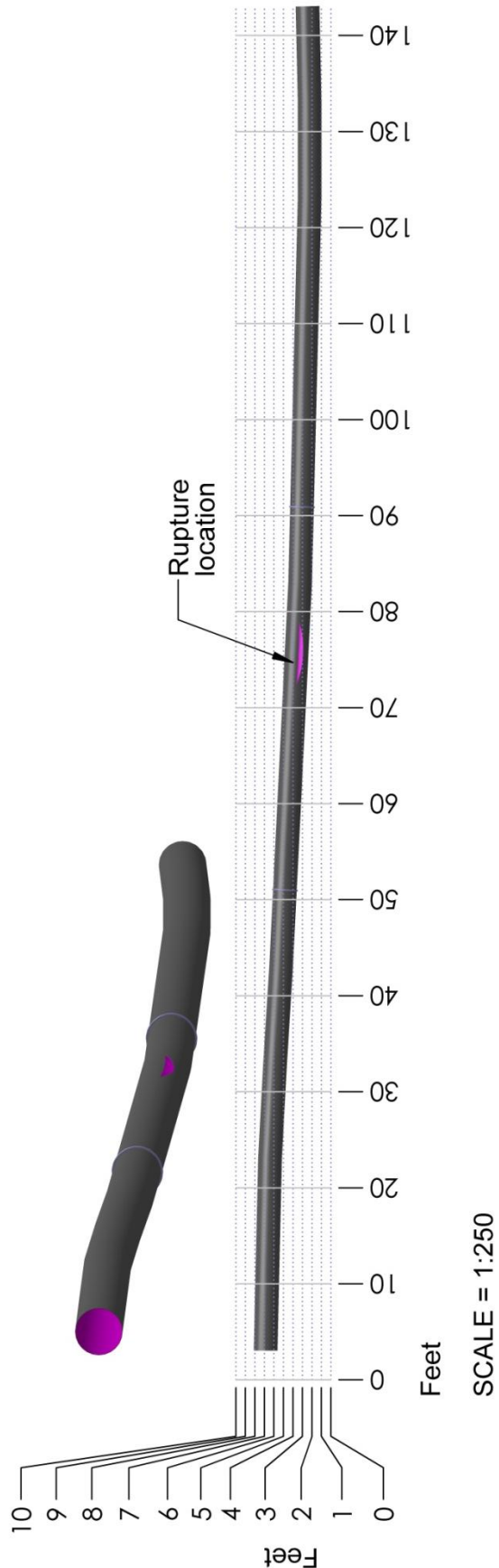
**Figure 5.** Drawing of the Line 6B ruptured segment, as surveyed following the rupture (right), with relative elevation differences shown.

Rupture location was at a measured elevation of approximately 910.5 feet ASL.

(See Attachment 14)



(above) ruptured segment out of trench. Polyethylene tape wrap coating (black) is only partially shown but covered the entire pipeline.



SCALE = 1:250

## **K. Attachments**

Attachment 1	IMP IR 31.1 Pipeline Description
Attachment 2	IMP 367 Pipeline History with Polyethelene
Attachment 3	IMP IR 373 Line 6B Shutdown History
Attachment 4	IMP IR 49 Pressure Restriction History
Attachment 5	IMP IR 24-5 Cathodic Protection Records
Attachment 6	IMP IR 33 Line 6B Service History for last 2 years
Attachment 7	IMP IR 1.13 Line 6B ongoing work requests
Attachment 8	IMP IR 20 Close interval survey Line 6B 30 Inche
Attachment 9	IMP IR 24.8 Line 6B leak history over 5 years
Attachment 10	IMP IR 43 Pipeline field survey
Attachment 11	IMP IR 9.1 Welding procedure specification
Attachment 12	IMP IR 81 Moody inspection reports
Attachment 13	IMP IR 82 Line 6B construction pressure test records
Attachment 14	IMP IR 80 Bill of lading and transportation of Italsider pipe
Attachment 15	IMP IR 107 Sectionalizing valves used at shutdown
Attachment 16	IMP IR 106 Line 6B Elev Profile GW 217550 to 217900.pdf
Attachment 17	IMP IR 24-9 Leak History.pdf
Attachment 18	IMP IR 368 Depth of cover